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GOVERNMENT OF INDIA

DEPARTMENT OF INDUSTRIES AND SUPPLIES

REPORT

OF THE

PANEL ON ARTIFICIAL SILK AND RAYON INDUSTRY

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PERSONNEL.

Chairman—

Dr. Nazir Ahmad, O.B.E., Ph.D. (Cantab), F. Inst. P.

Members—

1. The Hon'ble Sir Shanti Das Askuran.
2. Mr. Gautam Sarabhai.
3. Mr. M. P. Bhargava.
4. Mr. P. N. Sinha.
5. Mr. M. Subba Rao.

Secretary—

Mr. A. S. Bhatnagar, Assistant Industrial Adviser.

Mr. R. J. Chinai was subsequently co-opted as a member of the Panel.

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INTRODUCTORY REMARKS.

The Government of India in the Department of Planning and Development constituted a Panel to consider and advise them regarding the establishment of artificial silk and rayon industry in India in the post-war period.

GENERAL DIRECTIVE

II. The following general directive was issued by the Government of India to indicate the scope of the Panel and the procedure to be followed by it.

1. It is the function of panels to make recommendations to Government regarding the development of industries, both existing and new. These recommendations should be so framed as to enable Government to prepare a detailed phased plan for the five years following the cessation of hostilities, as the first stage of a 15-year plan of industrial development for the whole country.

2. In order to assist them to formulate recommendations, panels will be supplied, as far as possible, with factual information prepared by the panel secretaries. In the case of new industries, the information will consist of a general survey of the industry and the importance of starting it in India, the availability of raw material, the power-requirements, the demands of the Indian markets and the probabilities of exports. In the case of existing industries, the information will naturally be more comprehensive; it will indicate in addition, the location of existing units, the types of goods produced, the total production under each category and the assistance, if any, given by Government. These items are to be regarded as illustrative and not exhaustive.

   Government will give each panel, as a basis, for discussion, the provisional target to be aimed at in the first five-year period and, wherever possible, of the target to be reached in 15 years.

3. The recommendations of the panels should cover the following points:—

   (1) The scope and extent of development, including the type of products recommended,

   (1-A) The estimated requirements of capital goods together with such details of those requirements as may be available in India and how much should be imported from abroad.

(2) Whether the industry should be under Government ownership either on grounds of national interest or because private capital is unlikely to take it up, and if so, whether it should be wholly or partly managed by Government.

(3) In the case of industries to be developed other than under State ownership, the capital required for such development, whether the whole of it is likely to be available by public investment and, if not, the extent to which Government assistance may be required.

(4) The extent to which technical advice from abroad may be necessary.

(4-A). The availability and the future requirements of technical personnel so as to obtain a clearer indication of the present short-comings and future needs.

(5) The manner and the degree of co-operation with foreign firms considered necessary and desirable, both as regards capital and management.

(6) The location of the industry.

(7) The nature of the assistance required from Government in the form of protective duties, bounties research grant, expert advice, etc.

(7-A) The relative incidence of the import duty on the finished goods in comparison with the duty on the raw materials from which they can be manufactured.

(8) If the industry is to be under private ownership and management, what controls, if any, should be exercised by Government.

(9) What should be the organisation of the different units of the industry, *e.g.*, should there be an industrial association? Would a cartel be desirable?

(10) The stages by which the industry should be developed.

(11) Should the industry cater for the export market?

(12) Should the industry be developed, as in Japan, on the cottage industry basis and, if so, to what extent?

4. Although, as stated above, the panels may recommend the grant of protection, it will not be their function to consider broad questions of international trade and commercial policy.

5. Joint meetings of the panels should be held, wherever necessary, to secure co-ordination particularly where the processes and products of one industry are connected with those of another.

6. Some of the panels have been drawn broadly and it may be necessary to co-opt members for dealing with specific branches of the industry. Members may be co-opted by the Chairman in consultation with the Industrial Adviser.

7. Before submitting recommendations, panels should consult Provincial Industrial Committees, particularly in the matter of location of industry. They should also, where the circumstances of the case require it, consult Industrial Committees in States or State Governments—Durbars. The recommendations should be submitted to Government through the Industrial Adviser.

BRIEF ACCOUNT OF PANEL'S WORK.

III. A preliminary note containing factual information about the industry was prepared by the Secretary and circulated amongst the members of the Panel before its first meeting.

IV. The panel met on the following dates:—

(a) First meeting held on the 2nd and 3rd July 1945 at Bombay.

(b) Second meeting held on 28th and 29th August 1945 at Bombay.

(c) Third meeting held on the 12th, 13th and 14th February 1946 at Bombay.

(d) Joint meeting with representatives of Provincial and State Governments and their Industries Committees held on the 11th July 1946 at New Delhi.

(e) Fifth meeting held on the 18th September 1946 at New Delhi.

(f) Sixth meeting held on the 29th November 1946 at Bombay.

V. The Panel sought the advice of the following persons and representatives of associations at various stages of its deliberations:—

1. Dr. L. Thoria, Dr. Ing. (Germany), Bombay.
2. Mr. Ganga Raju.
3. Mr. DuPlant, Engineering Consultant, Bombay.

4. Sir Frederick Stones of M/S E. D. Sassoon & Co., Bombay.
5. Mr. Henry Kohorn of M/S. Oscar Kohorn & Co., New York.
6. Mr. Watson of M/S. Duncan Straiton & Co., Bombay.
7. Mr. Sankal Chand G. Shah—*Vice-President*
8. Mr. Morarji J. Vaidya—*Hony. Secretary*
9. Dr. A. Nagaraja Rao—*Chairman (Heavy Chemicals Sub-Committee).*
10. Mr. M. L. Badami—*Secretary.*

Representatives of All India Manufacturess Organisation, Bombay

11. Mr. Dhiraj Lal Schroff, Millowner, Bombay.
12. Mr. S. G. Sastry, Retired Director of Industries, Mysore.
13. Mr. R. P. Dessai, Technical Expert, Bombay.
14. Mr. I. P. Parikh of M/S Podar Sons Ltd., Bombay.
15. Mr. M. L. Narasimiengar, Chairman, Mysore Paper Mills Ltd., (Mysore State).
16. Dr. K. N. Rao, Deputy Industrial Adviser to the Government of India.
17. Mr. T. Blackburn of M/S. Dobson & Barlow Ltd., England.

ACKNOWLEDGEMENTS

The Panel is greatly obliged to these gentlemen and several other officials and non-officials for their willing help and valued advice.

VI. Grateful thanks of the Panel are due to the Chairman for his able guidance at the meetings and for his keen interest in the work of the Panel

VII. The Panel wishes to place on record its appreciation of the services rendered by the Secretary, Mr. A. S. Bhatnagar, in the collection of statistics, preparation of draft report and other duties connected with the work of the Panel.

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ARTIFICIAL SILK & RAYON INDUSTRY

Earlier Developments.—The story. of the development of artificial silk forms one of the most romantic chapters in the history of industrial research. After a long preliminary period of patient research, the artificial silk industry started in 1895—in France, the process employed being. the Chardonnent process. There was an initial period of uncertainty, after which the world output rapidly increased from a few hundred thousand lbs. in 1896 to 22 million lbs. in 1913. The constant improvement in the quality of the new fibre, the multiplication and extension of its uses, its cheapness and increasing familiarity of manufacturers with its possibilities, combined to produce a continued increase in the demand of artificial silk goods. Fashion in wearing apparel and the general prosperity of the working classes also favoured the more extensive use of this synthetic fibre. As the term artificial silk gave rise to misdescription and confusion, the American trade decided in 1924, to take the lead in discarding this title in favour of the neater and more comprehensive word "rayon" British firms followed suit in 1928.

2. *Types of rayon and modern trend.*—Various processes have been employed for the manufacture of rayon in industrially advanced countries such as the cup rammonium process, the cellulose nitrate process, etc., but the two more popular methods which have gained prominence and are in vogue are:—

(1) the viscose process;

(2) the acetate process.

The more common of these two is the viscose process, which on account of cheapness in the finer deniers, contributes to more than 80 per cent. of the total world production of rayon. The U. S. A. production of 573 million lbs. in 1941 consisted of approximately (1) viscose 63 per cent. (2) acetate 32 per cent., (3) cuprammonium 2 per cent.

One great advantage that viscose rayon scores over acetate rayon is its ability to take the same dyes as used for cotton. Unlike viscose rayon, which is regenerated cellulose, acetate threats consist of cellulose acetate and a special class of dyes is required for them.

3. During recent years, however, there has been a great demand for union fabrics in the United States of America. These fabrics are manufactured out of mixed acetate and viscose yarns. This trend along with recent advances that have been made in the dying processes have given a great impetus to the acetate rayon industry, and production of acetate rayon is steadily mounting up in the States and other European countries. The acetate industry has one special advantage. Its finished product which is cellulose acetate can be used for many purposes such as rayon, plastics, lacquers, etc. On the other hand staple fibre is made almost exclusively from viscose. The synthetic fibre industry is undergoing radical changes in Western countries and every day new fibres are being perfected. Many other synthetic fibres like Nylon and Vinyon are becoming popular and their use is finding favour in other countries particularly in the United States of America.

4. *World production of Rayon.*—The total world production of rayon yarn in 1942 reached the high figure of 1,447 million lbs. as compared to 48·2 million lbs. in 1921 (App. I). America has been the top manufacturer of rayon in the recent years. Its production of rayon was 479 million lbs. in 1942 as against a meagre production of 18 million lbs., in 1921. England, too, has made rapid progress in rayon manufacture. Its total production in 1942 has been estimated at 90 million lbs. (App. I). Rayon has not only been

successfully competing with cotton and genuine silk but has largely replaced them from the markets in Germany, France and Italy. In these countries it is believed that more than 50 per cent. of the clothing is made out of rayon. The production of rayon in Germany, Italy and France was 160, 119 and 56·2 million lbs. respectively in the year 1939 (App. I). The estimated production of 1942 for these countries was 220, 132 and 69·5 million lbs. respectively. The greatest advance in the production of rayon has, however, been made by Japan. With a relatively small production of 3·2 million lbs. in 1925 its production rose to 239·3 million lbs. in 1939 (Appx. I). This country flooded the world markets with large quantities of rayon yarn and fabrics which were available at amazingly low prices. The estimated rayon yarn production in 1942 was 300 million lbs. which were only second to U.S.A.'s estimated production of 479·3 million lbs. (App. I). Methods of production employed in Japan are kept secret but it is stated that among other raw materials they employed pulp from the coniferous trees growing in Manchuria.

5. *World Production of Staple Fibre.*—Despite a late start, staple fibre which is the name given to predetermined and equal lengths cut from rayon tow, has already passed the rayon yarn in the volume of world production. The world staple fibre production for 1942 was 2,026 million lbs. as compared to the yarn production of 1,447 million lbs. (App. II). The use of staple fibre has gained prominence because it can be used in admixture with natural fibres such as cotton and wool. It has been possible to work it on textile and woollen machinery with slight modifications. The American production of staple fibre in 1942 was 153 million lbs.

The estimated production of staple fibre in England, Japan, Germany and Italy in 1942 was 45,400,880 and 330 million lbs. respectively (App. II). The kind of rayon staple which has so far achieved the greatest volume both in United States of America and throughout the world is the viscose staple. So far it has been the cheapest form of rayon staples and attained peak production just before the war.

Case for the Establishment of the Industry in India.

6. *Consumption of Rayon in India.*—India is one of the leading textile manufacturing countries in the world. In 1941-42, the textile production in the country was 4,495 million yards as compared to 1,164 million yards just before the First World War. With the increase in production there has been a corresponding increase in the varieties of fabrics manufactured and Indian textile mills have been importing long staple cotton from the U. S. A., Uganda and Egypt, etc., in order to produce better and finer qualities. The advent of rayon brought a further increase in varieties of fabrics and Indian textile and silk mills began to import increasingly large quantities of rayon yarn. Import figures of rayon yarn in India (App. III) showed tremendous rise from a relatively small quantity of about 0·4 million lbs. imported in 1923-24, to 33·9 million lbs. (valued at Rs. 265 lkhs) in 1940-41. The total value of the imports of rayon yarn and manufactures was Rs. 544 lakhs in 1940-41 and Rs. 349 lakhs in 1941-42, the decrease being due to war conditions. Japan supplied over 93 per cent. of our requirements in 1940-41 and about 85 per cent. in 1941-42 (App. IIIa)

7. Imports of piece-goods made entirely of rayon were 53·3 million yards valued at Rs. 245 lakhs in 1940-41 and 27·7 million yards valued at Rs. 168 lakhs in 1941-42. Imports of goods of rayon mixed with other fabrics totalled 4·8 million yards valued at Rs. 28 lakhs during 1940-41. With the import of rayon yarn a number of rayon weaving factories were set up in the country. An attempt was made to obtain a complete list of the rayon weaving factories in India. The information so far as made available to the Panel is given in Appendix IV, but it may be presumed that this does not represent a complete

list of all the rayon weaving factories installed in India. In addition to the weaving factories using imported rayon yarn for making rayon fabrics, many cotton mills in India are now using fairly large quantities of rayon yarn in the manufacture of saree borders and other union fabrics. The use of rayon yarn in combination with cotton yarn has also spread to the handloom industry, and a very large number of handlooms are successfully functioning in the country. An estimate made in an article published in the December (1944) issue of the "Eastern Economist" puts the capital invested in the rayon weaving industry in India at about Rs. 2½ crores and the annual production at about 50 million yards of rayon cloth. It is estimated that not less than 8,000 power loom for rayon weaving are installed in the country.

8. India is a poorly clothed country. The consumption of cotton per head in India was only 3·5 lbs. in 1935 as compared to 23·1 and 17·3 lbs. in U.S.A. and England respectively in 1937 (App. V). Similarly the *per capita* rayon consumption in our country was only 0·10 lbs. in 1935 as compared to 2·88 lbs. and 2·51 lbs. in U. S. A. and England respectively in 1937. Germany led the world in her *per capita* consumption of rayon, the figure being 6·49 ibs. per head. Japan was a close second with 5·30 lbs. (App. VI).

Post War plans for this country are all directed towards increasing the per *capita* income of the people with a view to raising the standard of living. Better food and clothing should be the first consideration of every plan. This will naturally lead to increased consumption of rayon clothing in the country.

9. India is very favourably placed for the establishment of the rayon industry. In the first instance the large pre-war consumption and the anticipated post-war increase in themselves warrant for its immediate establishment. Besides, this almost all the raw materials required for its manufacture are or can be made available in the country in abundance. The case for the establishment of rayon industry in India assumes an added significance under the present conditions, because it is expected that Japan which supplied a major portion of India's rayon requirements in the pre-war period will not be able to offer severe competition for many years to come. In view of the above considerations and the fact that India should be self sufficient in her domestic requirements, this Panel is strongly of the opinion that the immediate establishment of this important industry in the country is essential in the post-war period. Our pre-war consumption of rayon was between 60 to 70 tons per day. In order to cover the pre-war demand by indigenous production, the Panel is of the opinion that there is easily room for 6 to 7 rayon factories (each having a daily production capacity of 10 tons) in India in the immediate post-war period with a possible addition of another 4 to 5 factories as our requirements increase owing to an increase in population and rise in the standard of living.

The Panel visualises that there will be a steady increase in the consumption of rayon in the country, mainly due to the following two reasons:—

(a) increase in population, which can be estimated with fair accuracy.

(b) rise in the standard of living, an estimate for which is difficult to make at present.

The extent of increase in rayon consumption will depend upon the rise in the standard of living, cost of its production and such foreign competition as might be anticipated in the post-war period.

10. Units of 5 tons and 10 tons production capacity per day which are considered as economical, are considered most suitable for this country in view of the need of developing the different regions and spreading out factories over a wide area. However, if other conditions are favourable, there should be no objection to the installation of bigger plants so as to reduce the overheads, etc.

The Panel is of the opinion that six out of these seven factories should be for the manufacture of viscose rayon (yarn and staple fibre) and in view of the modern trend of increased use of the union fabrics, at least one factory should be for the manufacture of acetate rayon. It should be remembered in this connection that our country is very favourably placed with regard to certain raw materials such as cotton waste, molasses (for acetic acid), etc., required for the acetate industry and estensive research work should be initiated to develop this industry.

The need for carrying out operations on a pilot plant basis are dealt with in paragraph 16. It is realised that even after this stage has been accomplished certain problems will have to be solved in actual factory operation since it is a new industry in India.

11. *Raw Materials.*—Cellulose is the main raw material required for the manufacture of viscose and acetate rayon. India abounds in cellulose bearing materials—cotton, bamboo, woods, bagasse, jute, reeds, sun hemp, akra floss, etc.

12. *Cotton.*—Cotton is the purest form of cellulose among the natural products. Chemical cotton which is the name given to chemically cleaned cotton contains over 99 per cent. alpha cellulose.

The cheapest source of chemical cotton is cotton linters. The actual production of linters in India before the war was estimated at about 15,000 bales of 400 lbs. each. This production, however, was far short of the potential supply as large quantities of cotton seeds, especially of the hirsutum variety were not delinted. It is difficult to make an estimate of the total potential production of linters in India, but it is estimated, even if a fairly large proportion of the linter bearing seeds of the Indian varieties were delinted, about 75,000 bales of linters representing about 30 million lbs. would be available annually. Cotton linters constitute the principal cellulosic raw material in the manufacture of acetate rayon and 1 lb. of the latter requires 0·7 lb. of cotton cellulose. Allowing for a waste of 40 per cent. (including moisture) in the preparation of cotton cellulose from linters it would appear that nearly 5 million lbs. of linters would be required for an acetate rayon factory having a production of 5 tons of acetate rayon per day. Thus, the potential production of linters in India is well in excess of the requirements of an acetate rayon factory. The balance of linters can profitably be used in combination with wood pulp in the viscose rayon factories to be established in India, and for the manufacture of plastics, lacquers, explosives, etc. It is well know that in America a very large and flourishing linter industry has been built up which supplies its material not only to the rayon industry but also to several other industries such as explosives, plastics, lacquers, etc. The Technological Laboratory of the Indian Central Cotton Committee has carried out an investigation on the grades, alpha cellulose content, etc., of Indian linters of two seasons, and the results of this investigation are published in a bulletin entitled "The Analysis, Grading and Utilisation of Indian Linters" by L. Thoria and Nazir Ahmad. The prices of linters prevailing at the time and the technical data obtained for them taken from the bulletin referred to above, are given in Appendix VII. The Panel very strongly recommends that early steps should be taken to make a survey of the potential supply of Indian linters and every assistance should be given by the Government for the installation of delinting plants at the oil mills and other centres for extracting linters from seeds before they are either pressed for oil or exported out of India. In this way not only a valuable raw material will be available for the development of several industries in India in which the linters are used as the basic material, but also the cultivators of cotton would be able to get a little higher price for their seeds.

In addition to these linters a very large quantity of cotton waste is available from the Indian cotton mills. While some of this waste is undoubtedly useful for spinning lower counts, other types of waste such as blow room droppings, cardfly, etc., are eminently suitable for conversion into chemical cotton. Thus taking the linters and lower grades of waste into account India would seem to possess abundant supplies of cotton cellulose for the rayon industry. Cotton cellulose is almost exclusively used in the manufacture of acetate silk, while in the manufacture of viscose silk it is mixed in varying proportions upto about 30 per cent. with cellulose obtained from wood pulp.

13. *Wood pulp and other pulps.*—The cellulosic content of wood-pulp, which is the principal cellulosic raw material used in the manufacture of viscose rayon, is about 90 per cent. which means that a factory having a production of 5 tons of viscose rayon per day will require about 5·5 tons per day of wood pulp. In European countries and in the United States of America, originally, soft wood such as spruce and fir, was used as the chief cellulose bases for the manufacture of viscose rayon. Later on these pulps have also been made from the southern pine, which is relatively hard, and are of equally good quality. The Scandinavian countries are among the principal suppliers of soft wood pulp to England and other neighbouring countries, while in Italy, rayon was said to be manufactured from a special variety of reeds known as Arunda Donax which is found abundantly in Assam. It has been stated sometimes that India does not possess large quantities of soft wood suitable for rayon. The paper and pulp Section, Forest Research Institute, Dehra-Dun are, however, of the opinion that abundant supplies of spruce and fire-wood are available in the Kashmir and Tehri-Garhwal forests. Attempts should be made to explore the possibilities of their economic transport to the plains by the more recently developed methods of transport.

14. *Bamboo.*—The experiments carried out at the Technological Laboratory, Indian Central Cotton Committee, Bombay, under the auspices of the Council of Scientific and Industrial Research have shown that bamboo, of which we have abundant supplies available in different parts of the country, may prove to be a very promising material for rayon. The Eta type of bamboo grown in Travancore State has yielded a good quality pulp with high alpha-cellulose content and low ash content. It is understood that before the war some samples of bamboo grown in the Karnatak forests (Bombay Province) were sent to Germany for tests. The report on these was not available to the Panel but the experiments, carried out in the laboratories of the German Rayon concern Glanz-Staff Fabriken, showed that this material might prove a satisfactory raw material for the manufacture of ryon. It should however be noted that until pilot plant experiments are carried out in which bamboo pulp is actually spun into rayon and the yarn and cloth obtained are given the sizing, dyeing and finishing tests, it is not possible to say definitely whether this materal would prove entirely satisfactory when used on a large factory-scale. Such pilot plant tests have to our knowledge not been performed so far, and the Panel has in the latter part of the report recommended that a pilot plant for this purpose should be set up at an early date in India. Bamboo, however, possesses an advantage over wood, in that it is a two five yearly crop, whereas coniferous woods take forty to sixty years before they become suitable for use as pulp wood. The cellulose content of bamboo is very nearly the same as that of wood, but the ash content of the pulp made from it is found to be somewhat higher than that of the imported wood pulp. This may lead to some difficulties in the spinning process such as clogging, but it should be mentioned in this connection that the ash content of the pulp can be reduced to some extent by physical and chemical treatment. Whether such treatment would be able to reduce the ash content to a limit at which pulp made from bamboo would be found quite suitable for rayon manufacture can

only be ascertained by experiments on a pilot plant, which is [illegible] ment in favour of the installation of such a plant in India at an early date, if this promising raw material is to be fully exploited for the rayon industry.

Pre-war average price of bamboo in India ranged between Rs. 16 to Rs. 18 per ton delivered at factory site. In certain areas it was even available at about Rs. 12 per ton. It is reported that in 1938, the cost of one ton of bleached babmboo pulp suitable for paper manufacture, worked out at about Rs. 140 per ton. Against this the price of imported bleached sulphite wood pulp, excluding the protective duty, was about Rs. 100 per ton. The present price per ton of imported bleached sulphite wood pulp from the U. S. A. is over Rs. 360 per ton delivered at port. With the aid of the protective duty, bamboo has established itself firmly in the Indian paper industry and has fair chances of being successfully used as the cellulose base in viscose rayon manufacture. Extensive research should, however, be carried out to standardise the technical details of making bamboo pulp suitable for rayon manufacture.

15. *Bagasse.*—Bagasse is yet another promising raw material, as it contains a good percentage of cellulose. The experiments carried out on the manufacture of bagassed pulp by the nitric acid treatment method, have shown that the pulp so obtained is quite satisfactory as regards the alpha cellulose content but contains a slightly high percentage of ash. The technical details of pulping bagasse have still to be worked out. It is quite possible that with the aid of further research and recent developments in the technical processes of pulping, bagasse may prove to be a suitable raw material for the manufacture of rayon. At present bagasse is being utilised as a fuel in the sugar mills, which is however not its proper use. About 2 million tons of bagasse are available from the sugar mills every year.

In addition to the above mentioned raw materials, we have abundant supplies of other cellulose bearing materials, such as hemp, reeds, grasses, etc. A preliminary survey of the cellulosic bearing raw materials of India has been carried out by Nazir Ahmad and Karnik under a scheme financed by the Council of Scientific and Industrial Research, and the results obtained have been published in the Journal of Scientific and Industrial Research in its issue of June 1944. It is necessary that this work should be followed up and extensive research should be undertaken to explore the possibilities of their use in rayon and other industries.

16. It will therefore be seen that India is very favourably placed with regard to cellulose which is the basic raw material for rayon manufacture, although extensive research work has to be carried out to work out the technical details, to estimate the cost of manufacture of the pulp and to standardise the quality of pulp made from the indigeneous raw materials. Authoritative statistical data about the total quantity of these raw materials available for pulping purposes is also not available. Under these circumstances the Panel is definitely of the view that in the initial stages at least it would be necessary to use imported wood pulp in the rayon factories to be established in India. The wood pulp suitable for rayon manufacture is made in special qualities with regard to alpha cellulose and ash content etc., and until pulp of the right quality can be manufactured in India, the rayon industry will have to depend upon foreign supplies for the basic raw material. This position, however, is fraught with a certain amount of risk, as in war time or due to other causes, these supplies may be completely cut off or considerably curtailed, thereby placing the industry in perilous state. The Panel, therefore is very strongly of the opinion that the use of indigenous materials should be encouraged and developed simultaneously with the establishment of the rayon industry so that India may not remain dependent upon foreign suppliers for an essential raw material. For the exploitation of the Indian raw materials the Panel makes the following recommendations:—

(1) As no reliable statistical data on the availability of cellulose raw materials is available, the Government is requested to arrange for the carrying out of an immediate survey of all cellulosic raw materials including soft and hard

wood, bamboo, grass, other reeds, cotton linters, cotton wastes etc., available in the country. This survey should be carried out through the Department of Agriculture, Government of India, who should appoint special forest officers in the different regions for collection of statistical data and should be given a special grant for this purpose. For carrying out this survey priority should be given to those regions where the location of new units is indicated by the Panel or where the natural resources are available in plenty.

(2) In view of the facts that (*a*) rayon manufacture is a highly specialised industry, (*b*) the utilisation and exploitation of the Indian raw materials have not been systematically studied, (*c*) the costs of manufacture under Indian conditions have not been properly worked out, it is essential that Government should take steps to establish a semi-comercial plant of a capacity of about 100 lbs. per day for preparing the pulp and about 100 lbs. per day for spinning the yarn, complete in every respect. The installation of a complete pilot plant is also necessary from the consideration that the mere knowledge of the physical and chemical properties of a pulp is not sufficient to determine its suitability for rayon manufacture, which can only be ascertained by performing an actual spinning test, followed by the dyeing and finishing processes. The proposed pilot plant will not only materially help in the solution of the above problems and other technical research problems of the industry but will also assist in creating confidence in the public mind.

17. *Chemicals.*—The chemicals required in the manufacture of rayon are:

Viscose rayon—

1. Caustic soda.
2. Sulphuric acid.
3. Carbon disulphide.
4. Glucose and other sizing materials.
5. Sodium sulphate.
6. Sodium sulphate.
7. Sodium sulphide.
8. Zinc sulphate.
9. Zinc oxide.
10. Sodium hypochlorite.
11. Hydrochloric acid.
12. Formic acid.
13. Softening oils.

Acetate rayon.—

1. Acetic acid.
2. Acetic anhydride.
3. Acetone.
4. Sulphuric acid.
5. Softening oils & sizing materials.
6. Sodium acetate.

सत्यमेव जयते

It is interesting to note that the manufacture of 5 tons of viscose rayon requires the use of about 20 tons of chemicals. The following approximate quantities of chemicals (as supplied by a British manufacturer) are required for the production of 1 ton of viscose rayon.—

	(In tons)
Wood pulp	1·200
Caustic soda 99% ..	1·000
Carbon bi-sulphide ..	0·350
Sodium sulphite ..	0·073
Dialysing material ..	0.00052
Sulphuric acid 77% ..	1·650
Zinc oxide ..	0.017
Glucose 80% ..	0·037
Sodium sulphide 66% ..	0·100
Formic acid 66% ..	0·012
Soft finish ..	0·0025

18. It can be seen that the development of the Rayon industry is closely linked with the development of the heavy chemicals industry in India and the location of rayon plants should take into account the facilities available for the manufacture of these major chemicals near the sites. It is essential that the rayon plants should have plants for the manufacture of carbon-bisulphide on the spot as this chemical is somewhat inflammable and cannot be safely transported from one place to another. It would also be desirable if the rayon plants especially the bigger units had their own plants for manufacturing sulphuric acid at or near the factory thereby saving freight charges, middlemen's profits, etc. It is estimated that the cost of a contact process sulphuric acid plant capable of satisfying the requirements of a 5 ton rayon plant would be in the neghbourhood of Rs. 3½ lakhs, which is a small proportion of the capital required for the rayon machinery. The cost of production of the sulphuric acid at the rayon factory will in all probability, be lower than the market price owing to saving in overheads and profits. It may also be an advantage to have the caustic soda plant at or near the rayon factory so that the caustic soda liquor can be supplied in drums which would not only save freight but also the expenses on converting it into sticks or flakes and redissolving it. Since, however, the manufacture of caustic soda is linked up with the manufacture of almost an equal quantity of chlorine, which is not wholly required in the rayon industry and for which a separate market has to be found, the problem of locating the caustic soda factory, as a part of the rayon factory is not so simple as that of carbon-di-sulphide and sulphuric acid. It has to be examined from a different angle especially from the point of view of the marketability of chlorine and its subsidiary products such as bleaching powder. Regarding the location of the caustic soda plant at the side of the rayon factory the Panel feels that each case should be decided on its own merits. For factories located near large chemical producing centres like Bombay and Calcutta, it may not be necessary for rayon manufacturers to produce their own caustic soda, while for rayon factories situated at places far away from these centres it will be a distinct advantage to instal caustic soda plants at the sites. Since large quantities of chlorine will be made available by the installation and working of the electrolytic plants for manufacturing caustic soda, the Panel strongly feels that Government should extend the use of chlorine for public health purposes and also for the manufacture of D.D.T. and plastics etc. The attention of the Heavy Chemicals Panel is drawn to this recommendation. In connection with the chemicals required in the manufacture of rayon, it should be noted that in many cases, chemicals of commercial purity will not serve the purpose, and they must be of a high degree of purity satisfying certain specifications arrived at as a result of extensive research and long experience by the industry. For Example, the caustic soda used in the rayon industry should have a chloride content not exceeding 0.2 per cent while its chlorate content should be practically nil. This can be achieved by further purification of the caustic prepared in the diaphragm type electrolytic cells or directly in a mercury electrolytic cell. Similarly, the purity of glucose should be of the same standard as demanded in the baby food industry. The water used in the washing and other processes should be soft and free from iron, while sulphuric acid and sulphates required by the industry should be of high grades of purity. This aspect of the problem therefore assumes special significance, and should be carefully considered, when plans are made for installing the plants for the manufacture of chemicals required by the rayon industry. Furthermore, in view of the large quantities of chemicals used in the manufacture of rayon, the Panel feels that there should be a close co-ordination in the execution of the plans and recommendations of this Panel with those of the Heavy Chemicals Panel, especially in regard to the location of the factories where the question of the availability of chemicals of the right quality assumes special significance. The position regarding the production of the dfferent chemicals for rayon manufacture in the country is as follows,—

19. *Caustic soda.*—Caustic soda is one of the basic chemicals used in several

important industries such as textiles, paper, soap, explosives, dyestuffs, vegetable oils, etc. On the basic of unrestricted off-take our present consumption of caustic soda is about 54,000 tons annually. The present production capacity of the Indian factories is about 5,700 tons per year rising upto 11,700 tons in 1948-49, while with the installation of 4 electrolytic plants which have been ordered from abroad, it may go upto about 19,000 tons. Even with this increase the Indian manufacture of caustic soda will be far short of the country's demand which is estimated at about 70,000 tons per annum. The six units of rayon when installed will require an additional supply of about 30,000 tons of caustic soda per annum, which will have to be met with either from imports or by the installation of additional plants.

20. *Sulphuric acid*.—The production of sulphuric acid is rightly said to be the index of a country's industrial development. The production of sulphuric acid in India in pre-war days was estimated at about 26,000 tons per annum. This quantity was supplemented by imports. The present war has given a great fiillip to this industry on account of its increased demand for defence requirements. The present production is estimated at about 60,000 tons per year calculated in terms of 100 per cent. strength. The rayon industry will require about 34,000 tons of sulphuric acid.

In addition, large quantities of sulphuric acid will be required by other industries which are numerous in number and which are proposed to be established in the post-war period. It is, therefore necessary that the requirements of the rayon and other industries in regard to sulphuric acid in the post-war period should be taken into account while preparing plans for the development of this industry in India. The manufacture of sulphuric acid in India depends primarily upon the unrestricted supply of sulphur at competitive rates. In the opinion of the Panel therefore, it is essential that the Government should pay special attention to this point and should make the provision for the supply of adequate quantities of sulphur of a high degree of purity at fair prices to the Indian manufacturere of sulphuric acid. Furthermore, the high prices charged at present by the Indian manufacturers for sulphuric acid, which enjoys a virtual protection owing to transport difficulties act as a severe handicap to the development of all industries including rayon in which this chemical is used. These prices bear little relationship to the prevaling price of sulphur, and are considerably higher than those at which sulpuric acid is made available to the industrialists in other countries such as England and the U.S.A., thereby placing them at a definite advantage. The Panel strongly feels that Government should look into this question at an early date with a view to stabilising the price of sulphuric acid at a reasonable level and making it available to the consumers at this price.

21. *Sizing Materials and other Chemicals*.—Before the war, glucose and other sizing materials were all imported from abroad, the total quantity of sizing materials imported being in the neighbourhood of 100,000 tons per annum. During the war many factories, large and small sprang up in different parts of the country and were able to satisfy the requirements of the textile industry which were curtailed to about half the pre-war level by means of control orders. If these control orders continue and the position as regards certain foorgrains from which starch is made, improves these factories would be able to supply the demands of the Indian textile industry. If the seven units of rayon industry, however, are established according to the recommendations of the Panel, they will require another 10,000 tons of sizing materials per annum. Furthermore, if the control orders restricting the use of sizing materials, are relaxed, there will be an increased demand for the sizing materials for which additional factories will have to be established if India is to supply the total equirements of this commodity. Therefore in making plans for the establishment of sizing materials industry, the future requirements of the textile

industry plus the requirements of the rayon industry, amounting to about 10,000 tons per annum should be taken into consideration.

22. *Acetate Rayon Chemicals.*—The Indian production of acetic acid before the war was confined to the wood distillation industry in Mysore with a capacity of about 200 tons per annum, but the actual production came to only 50 to 60 tons, which was being sold as calcium acetate. During the last two or three years they were supplying the calcium acetate to the Ordnance Factory at Aravankadu for manufacture of acetone. As the Ordnance Factory has now installed its own plant, Mysore has again started manufacturing acetic acid. Hyderabad Chemical and Fertiliser Co., have recently set up a plant of about 150 tons capacity, while the Bhadravati plant in Mysore is being extended to bring the production upto 300 tons per annum. The production of acetic acid can be greatly increased in the post-war period. Alternative methods of production of acetic acid from (1) calcium carbide, (2) oxidation of alcohol, should also be investigated. With the development of the hydro-eolectric projects in the post-war period the calcium carbide method of manufacturing acetic acid presents bright prospects. As regards the other source of acetic acid many sugar mills have already installed fairly large sized distilleries in which alcohol is produced from molasses. Under suitable conditions it can be oxidised to give acetic acid, but the economic aspect of this method must be carefully worked out. The production of power alcohol is bound to increase as other distilleries are set up in the country, and a part of it can be utilised for the manufacture of acetic acid. There has been no production of acetic anhydride in the country on a commercial scale, but it is understood several Indian industrialists are exploring the possibilities of manufacturing acetic acid from molasses or alcohol.

23. *Acetone.*—Acetone has been manufactured on a very small scale in India. The Aravankadu Ordnance Factory was producing 14 tons of acetone per month from calcium acetate, but it has now set up a plant for manufacturing 75 tons of acetone per month from alcohol. Their output however may not be available for civilian needs. With the development of the power alcohol and wood distillation industries in India, the production of acetone is bound to increase as it has many other uses. The requirements of an acetate rayon factory will be in the neighbourhood of 2,500 tons per annum, provided a suitable recovery plant for acetone is installed. In this connection it may be noted that the success of an acetate plant depends upon the efficiency of the recovery plants both for acetone and acetic acid.

24. The Panel feels that there are good prospects for developing the acetate industry in India for which the chief raw materials such as cotton linters, cotton wastes, molasses, power alcohol etc., are abundantly available in the country. Apart from the acetate rayon which is finding increasing use in U.S.A. especially in the union fabrics, this industry will be a feeder to many other important industries such as plastics, lacquers, cinema films, etc. It is, however, necessary in the opinion of the Panel that the technical and economic aspects of the acetate industry, including the manufacture of chemicals required for it, should be thoroughly investigated on a pilot plant scale for which the necessary funds should be found by the Government.

25. *Uses of Rayon.*—The earlier uses of rayon were as a substitute for natural silk in certain fabrics, i.e., the fabrics were woven with rayon weft and silk warp and vice versa, thus lowering the cost of the materials. With the development of new methods and machinery and with a growing realisation of its characteristic qualities the use of rayon has gradually extended to every variety of textile. It is difficult to enumerate all the different types of goods in which it finds use, but the more important ones include sarees, shirtings, suitings, underwear, hosiery especially in admixture with other yarns, all varieties of embroidery and knitting yarns, neckties, coat linings, brocades, upholstery materials and parachutes. Apart from the continuous filament, the staple

fibre, has found an increasingly large use in the textile industry. Beginning with a modest production of 7 million pounds in 1929, its production in 1942 amounted to over 2,000 million pounds, representing nearly 60 per cent. of the total rayon production. The staple fibre is uniform in regard to length, fineness, diameter etc. and therefore constitutes an ideal spinning material. In addition, it can be blended with such natural fibres as coton wool, silk waste etc., and the blended mixture, or the pure staple fibre, can be spun upon the existing cotton, wool or silk machines with a few minor modifications. These advantages lend a special charm to it, and it is clear that in view of the highly developed cotton industry in India, any scheme for the establishment of rayon industry in the country must take into account the production of staple fibre on an adequate scale. The last great war has brought the synthetic fibres into prominence, and several new use of rayon have been found. It has been used (i) in the manufacture of incandescent mantles for kerosene lamps, bathing suits, shoes and corset nets, (ii) in rubberising rain coats and other military articles, (iii) in making self sealing or bullet sealing gasoline tanks, (iv) in the manufacture of cords for motor and aeroplane tyres. A table given in Appendix VIII shows the various uses to which rayon has been put in the U.S.A. and the quantities taken up for each line of consumption.

26. *Rayon Machinery.*—There is perhaps no other industry, which has been developed with the same rapidity as rayon. This Industry, though only half a century old, possesses today a vast literature of patents and publications. The improvements that have been made in the process of rayon manufacture, have been both on the mechanical & chemical side of the industry.

One notable improvement that has been made is in the spinning system. Two methods are in vogue (*i*) Bobbin or spiral spinning, (*ii*) Pot spinning. In the first method, as the name suggests, the coagulated thread is wound in bobbins or spirals. In the other system, the coagulated thread is led into a rapidly rotating pot whereby it gets a twist and by centrifugal force collects round the wall of the pot, from where it is removed as a cake. Both methods have the special features but during recent years rayon manufacturers have preferred the use of the pot spinning method.

More recently continuous methods of viscose preparation and rayon spinning have been evolved in America and the Continent of Europe. In Europe emphasis has been laid on continuous steeping and ageing of alkali cellulose whereas in America a continuous system of spinning, which includes bleaching, has been developed in recent years. Both systems are of great interest and specially in respect of the latter there is a reduction in man hours per pound or rayon; but even in America where this system was developed it has been tried only in one factory which is responsible for about 10 per cent of that country's rayon production. It is therefore to be seen how far the continuous process can be universally adopted. The future will reveal whether this system which has significance in countries like England and the United States of America where the rates of pay are high could become economical in India where wages are not so high.

27. The Panel considered the question of supply of rayon plants and the prices quoted for them by the foreign manufacturers. In this connection the Panel had the advantage of considering some quotations quoted by American and British firms which were furnished through the courtesy of members and technical experts who attended the meetings of the Panel. It was generally felt that the prices quoted by the foreign manufacturers were on the high side. It was also felt that the Indian industrialists intending to purchase rayon machinery from abroad should make a thorough examination, with the help of technical experts, of the type, efficiency and productive capacity of the plants for which the quotations are submitted to them, and provided they are satisfied that the plant would fulfil these conditions, they should try to purchase them at as low a price as possible.

in order to keep down the capital cost and the depreciation account. Apart from U.S.A. and Great Britain, the possibility of obtaining rayon plants or their component parts, at competitive prices, from other European countries such as Switzerland and France should also be explored. It should be noted in this connection that there are very few firms which fabricate the complete rayon plant, but in most cases the different component parts are manufatured by different manufacturers according to the specifications of the buyers. The Panel, therefore, feels that while an attempt should be made to obtain efficient rayon machinery at the lowest possible cost, foreign technical experts and consulting engineers should be consulted at every stage to ensure that the plant is properly balanced and its various components fit into it in a harmonious manner. The Panel also feels that as long as the present restrictions on exchange prevail, it may not be easy for the Indian industrialists to obtain supplies of rayon machinery from U.S.A. and other foreign countries, and therefore the Panel wishes to urge upon the Government the necessity of relaxing these restrictions at as early a stage as possible in order that quotations may be obtained in a free and competitive market and that the choice of the Indian buyers may not be restricted to certain types of machinery. The Panel strongly urges upon the Government to grant high priority to rayon machinery in the matter of facilities for import of capital goods. The Panel also feels that in the initial stages, until normal conditions return and prices quoted by the foreign machinery manufacturers are brought down to reasonable levels, the rayon industry should be revieved of the import duty on machinery.

28. The total value of plant machinery required for the industry, calculated on the basis of the present prices quoted by foreign manufacturers (average Rs. 2 crores for a 10 ton unit), is estimated at about Rs. 15 crores for the proposed seven units each of 10 ton daily production capacity. The cost of buildings, erection etc. will be extra.

29. In order to reduce the cost of the plants and encourage the indigenous engineering industry the Panel considered the possibility of manufacturing certain parts of the rayon plants in India. In this connection the Panel sought the advice of two engineering consultants, who were of the opinion that a number of minor parts can be successfully manufactured in India.

It is hoped that a reduction of 10 to 15 per cent. can be effected in the cost of the imported capital goods by getting some parts of the plants manufactured in India provided detailed drawings and blue prints from the manufacturers are available. The Panel is of the opinion that in view of the highly technical nature of rayon manufacture, it would be necessary to obtain help and assistance from foreign manufacturers. The Panel further feels that foreign manufacturers supplying the plants to India should send a sufficient number of qualified technicians for erecting and working the plants up to the specified production in the initial stages and should also bind themselves to train a certain number of Indian personnel at their work. The factories when established in India, should give preference to technically trained men, and should guarantee to employ a certain number of such men on adequate terms.

30. *Reparations from Enemy Countries.*—The Panel feels that if, as it is believed likely to be the case, any share of the plants existing in enemy countries should fall to India's share under the head of reparations, the requirements of rayon industry should be kept in view. In particular, it is felt that good use can be made in this country of Japanese rayon machinery. The Panel strongly recommends that at least a few rayon plants should be brought to India by way of reparations, along with foreign experts who should run them in the initial stages. The Panel further recommends that one of these plants, under Government management should be installed for public demonstration and should be worked by foreign experts, so that all the industrialists interested in the establishment of rayon industry in India, should have an equal opportunity of seeing

it in actual operation. This plant can also be used for training a certain number of technicians who will be required by the industry, and for carrying out tests on a commercial scale on Indian raw materials, the results of these tests being available to the country as a whole. This measure will greatly help in the establishment of this new industry.

31. *Technical Personnel and Labour.*—The panel is advised that the following superior technical staffs is required for the management of a rayon factory:—

(a) One Chief Engineer. (b) Two Asstt. Engineers.

(c) One Chief Chemist. (d) Two Asstt. Chemists.

(e) Three Foremen. (f) Four Laboratory Chemists.

(g) One incharge, Spinning Deptt. (h) Two girls for picking the yarn.

For a 10 ton plant, the number of other technical staff required is between 15 to 30. In addition, one analytical chemist in-charge of analysis and tests on raw materials and products at various stages of manufacture is needed. Besides these technical men, about 800 workers will be required for a 10 ton plant. They should be efficient and intelligent as delicate materials have to be handled at various stages. The Panel is of the opinion that suitable arrangements for general as well as technical education should be made by the factories to develop the efficiency and general knowledge of the workers. It is also of the opinion that the factories should put into force definite schemes whereby bonuses or extra wages are given to those workers, who give higher production or show greater efficiency, in order to stimulate the workers to put in their best efforts. Such schemes are now in vogue in the advanced factories in America and Russia and have yielded highly useful results. The Panel suggests that details of such schemes should be obtaised from these two countries and circulated to the industrialists to enable them to prepare schemes suitable to Indian conditions.

32. *Location of Industry.*—Regarding the question of general location of industry and sizes of plants, this Panel endorses certain recommendations of the National Planning Committee which are as follows:—

(1) In the matter of location of industries, the claims of the industrially backward areas should be given special consideration, subject to economic considerations justifying the same.

(2) With regard to the location of industries, equal opportunities should be given to every federating unit subject to economic consideration, of employment of labour and development of natural resources, provided similar conditions of work and wages prevail in the unit under consideration.

(3) As regards the size of the units, it is recommended that no unit should be so large as to be outside the reach of competition by smaller but economic units. Units smaller than the economic units should not ordinarily be allowed to be started, except for experimental or pioneer purposes. The side of the economic unit will be decided in the case of each industry by qualified authority.

33. *Dispersion of Plants.*—The dispersion of industry in the different regions of the country is essential for any planned economy. World War II has also shown that large concentration of industry in small areas is full of great risks, as it can lead to the complete destruction of the plants by enemy action especially from the air, thereby dislocating the industrial economy of a country and sapping its power of resistance. The distribution of raw materials and finished products and the employment of labour in the different regions lend further points in favour of dispersal of the rayon manufacturing industry. The Panel, therefore, considers that the rayon factories should be evenly distributed in the different areas taking into account such essential factors as raw materials, markets for finished products, power, transportation, etc.

34. For the successful working of any industrial venture, the selection of a suitable site is of vital importance. For a rayon factory the selection of a site is influenced *principally* by the following factors:—

(*i*) Availability of pulp and chemicals;

(*ii*) Abundant supply of water;

(*iii*) Power and fuel;

(*iv*) Transport facilities;

(*v*) Arrangements for the disposal of effluent.

(*vi*) Availability of labour, technical advice and workshop facilities;

(*vii*) Climatic conditions;

(*viii*) Markets.

35. *Availability of Pulp and Chemicals.*—Alpha cellulose, whether derived from imported wood pulp or indigenous raw materials, such as cotton, bamboo or bagasse, should be readily available near the rayon factory. A pulping unit manufacturing rayon pulp for a plant producing 5 to 10 tons of rayon will not be an economical proposition. The Panel, therefore, feels that the help and co-operation of the Indian paper mills should be sought to manufacture the special qualities of pulp required by the rayon industry. The possibilities of establishing large sized pulping factories, each producing about 40 to 50 tons of rayon pulp per day were also explored, but it was felt that it may not be advisable to establish large sized pulping factories in India due to lack of availability of raw materials in one area, abnormal railway freights necessity for dispersal of units etc. The pulp required for rayon should be of the very best quality containing a high percentage of alpha-cellulose and very low percentage of ash. Since it may be economical for a pulping factory to prepare pulps of different grades so as to utilise most of the raw materials available in the vicinity, it would be desirable to set up a pulping factory not only to manufacture pulps of high grade for the rayon industry but pulps of lower grades for other industries such as paper, boards, plastics, etc., which do not require either high alpha content or can work with pulps of relatively high ash content. In this manner the pulps of various grades made at the factory referred to above could be utilised by the different industries taken as a whole, and it is suggested that in selecting the site upon which the pulping factory is to be established requirements of other industries such as paper, boards, plastics, explosives, etc., should also be taken into account and should be co-ordinated. Whereever possible these other industries should also be situated either fairly near or within easy reach by sea or rail of the large pulping factory so as to keep the transport charges as low as possible and enable the pulping factory to dispose of its pulps of various grades to the consuming industries in an easy manner. In this connection it should be noted that fairly large quantities of caustic soda and other chemicals would be required by the pulping factories for the chemical treatment of the raw materials such as bamboo, reeds, timber, etc. If these chemicals are not manufactured near the site of the pulping factory, the question of their transportation at low rates to the pulping factory should be tackled so that the pulps in India can compete in price with the imported pulps. In addition to these chemicals large quantities of fresh water would be required for washing and cleaning he pulps, but it is assumed that there will be no difficulty in this respect.

36. It has been said before in this report for the manufacture of 1 ton of rayon, more than 4 tons of chemicals are required. This fact leads to the conclusion that the availiability of chemicals near a rayon factory is of no less importance. Sulphuric acid, caustic soda and carbon disulphide are the three basic chemicals used in the manufacture of viscose rayon. From these, carbon-disulphide will have to be produced on the spot as it is a highly inflammable material and its transportation over large distances, whether by rail or river is not advisable. Sulphuric acid and caustic soda can easily be transported in

drums and casks, but in order to keep down the transportation charges, it would distinctly be an advantage if the factories for the manufacture of these two chemicals, which will be required in very large quantities, are situated fairly near the rayon factories. If the caustic soda factory is situated fairly near the rayon factory it will have the additional advantage that it would not be necessary to evaporate the caustic liquor in order to produce sticks for transportation. In this way caustic soda will be available to the factory at a lower cost. From the foregoing analysis it would be clear that the areas which have good possibilities of developing the heavy chemicals industry should receive special consideration in the matter of locating the rayon factories in India.

37. *Abundant Supply of Water.*—Rayon manufacture requires large quantities of soft water. Impurities such as aluminium, calcium and magnesium, which are sometimes present in water, should be carefully removed. Water should also be free from colour, turbidity, excessive bacterial content and other organic impurities. It is estimated that 1 lb. of viscose rayon and 1 lb. of acetate rayon require about 70 and 1,000 gallons of soft water respectively during processing. The water requirement of a 5 ton viscose rayon plant will thus be in the neighbourhood of 3/4 million gallons per day, while the water requirements of a plant of the same size producing acetate rayon will be in the neighbourhood of 11 million gallons per day. It is therefore essential that constant fresh and abundant supply of soft water is available near a rayon factory.

38. *Power and Fuel.*—The problem of cheep power is of vital importance to this industry since fairly large amounts of power are required for working the rayon plants and the refrigeration units etc. Power required per lb. of rayon is between 3.5 to 4.2 K.W.H. while the steam consumption is stated to be about 70 lbs per lb. of rayon. The rayon factory should therefore be preferably situated at a place where cheap hydroelectric power is available or can be generated at a low cost from a thermal station, using coal as fuel. In the latter case arrangements should be made for generating steam at a high pressure, so that the bled steam, after working the power plant, may be used in the dyeing and finishing processes. Since a rayon factory works continuously for 365 days in the year and stoppage of work for a number of days is likely to inflict severe loss, arrangements should be made for the supply of energy from a stand by source, if the main supply is cut off at any time. At places where coal is available at cheap rates, it will be economical to put up thermal stations in which turbo generators should be installed for power requirements and the bled steam should be used for processing. Another factor which should be taken into account in selecting suitable sites for the projected rayon factories is the availability of coal at reasonably low prices. It is estimated that about 12 tons of coal (both for steam and power generation) would be required in the production of 1 ton of rayon thus placing the total requirements of a 5 ton per day rayon factory at about 22,000 tons of coal per annum. Since the coal fields in India are localized in certain areas, the transport charges from these areas to distant centres, which from other considerations may be regarded as suitable for rayon factories, may be quite heavy, and it may be more economical for these factories to use fuel oil instead of coal. The Panel therefore, suggests that the Government may consider sympathetically the question of removal of duty on imported fuel oil with a view to helping the establishment of this industry especially in areas near the ports where the supplies of Indian coal may not be had at competitive prices.

39. *Transport Facilities.*—Transport facilities, particularly in a country like India, where distances are large, are bound to play a decisive role in the future location of industry. In the case of the rayon industry, it assumes added importance because a ten ton daily capacity unit would necessitate movement of approximately 70 tons of materials (excluding coal). It would be more advantageous, if sea or river transport is available, provided other factors

are not adversely affected. Transhipment on a large scale should be avoided as far as possible in view of the nature of products to be handled.

Apart from the supply of raw materials, coal, etc., the question of markets for the rayon yarn and staple fibre should be taken into consideration in deciding on the location of the factories while the use of rayon fabrics is spread over the made great progress in certain provinces such as Bombay and the Punjab. Similarly, the consumption of staple fibre in admixture with cotton would be highest where the cotton mills are concentrated as in Bombay, Ahmedabad, etc. These factors should therefore be taken into account so that the incidence of freight on transporting rayon yarn and staple fibre from the factories to the consuming centres may be as low as possible and the consumers may be able to get their requirements of rayon goods at low prices.

40. *Disposal of Effluent.*—As has already been stated, rayon manufacture requires large quantities of fresh water, which after treatment with chemicals becomes polluted and unsuitable for any other use. It is therefore essential that adequate arrangements should be available for its disposal. It is understood that fairly inexpensive commercial plants (costing about 15,000 £ for a rayon factory of 5 to 10 tons per day capacity) are now available for treating rayon effluents so as to make them practically harmless.

Much of difficulty can be solved internally by an efficient and economic procedure. Recovery of Caustic soda in the Steep Department by Dialysis obviates disposal of large quantities of Caustic. Likewise Acid Regeneration is advantageous for economy reasons, and also in obviating the disposal of large quantities of acidic liquors.

The principle of treatment frequently adopted is to blend the acid and alkali liquors in order to neutralise the mixture with the help of an automatic P.H. recorder and then to aerate the liquor in order to reduce its oxygen absorption value and finally to allow the solution to settle down in settling tanks for the removal of sulphur. The neutral liquor thus flows out into a stream, creek or sea. In any case it is necessary that this factor should be carefully thought out when locating a rayon factory and an outlet or other suitable means of disposal should be provided for the contaminated water in such a way that it does not interfere with agricultural areas, irrigation or water supply system. It should also be noted in this connection that these effluents are fatal to fresh water fish, and therefore they should not be poured out into any streams in which fishing is carried on at present or is likely to be carried on in the near future. In view of the shortage of protein foods for the Indian population, the development of fish industry to provide additional sources of protein is very essential. This development should not be checked by the flow of effluents in rivers and streams which are used as nurseries for fish, and it is suggested that the Provincial and State Government and their municipal or local bodies should pay special attention to this point when giving licences to rayon factories proposed to be established in the different areas.

41. Keeping in view the above factors the Panel considered a large number of sites for rayon factories. This point was also considered at a joint meeting of the Panel with the representatives of Provinces and States, and the following sites are considered tentatively as being suitable locations for rayon factories in India. It should, however, be mentioned that the Panel had no opportunity of inspecting any of these sites and that proper surveying should be done before a particular site is finally selected.

1. Kalyan, North Kanara and Bhutkal in Bombay.
2. Chanda and Hoshangabad Districts in Central Province & Berar.
3. Kangra District in the Punjab.
4. **Banbassa area for acetate factory and Rihand scheme area for viscose factory in the United Provinces.**

5. Near Mettur Dam or Nellore District in Madras.
6. Near Calcutta in Bengal.
7. Cuttack District in Orissa.
8. Sind (for acetate factory).
9. Near Krishnarajasagar Dam in Mysore State.
10. Travancore State.
11. Hyderabad State.
12. Rewa State (pulp factory in the first instance).

In addition the possibilities of locating rayon factories in Assam and Indore State should also be investigated.

ORGANISATION OF INDUSTRY.

42. *Sizes of Plants.*—In the U.S.A., Japan and other advanced countries the capacities of rayon plants vary between 2 tons and 20 tons per day, but 5 and 10 ton plants are reported to be quite economical. Considering the conditions prevailing in this country the Panel is of the opinion that plants of 5 and 10 tons per day production capacity would be most suitable. The Panel further considers that in the event of increased demand for rayon goods in the country which might necessitate the setting up of more units, the question might be considered whether it would be a better proposition to establish these units in the different parts of the country or to extent the existing units so as to give increased production. It is not possible to express any definite opinion on this point at this stage, but it is hoped that the experience gained from the working of the first units set up in the country will throw light upon this point. It is, however, suggested that the units which are now proposed to be set up, especially those having a capacity of 5 ton output per day, should, as far as possible, make due allowance for extension at a future date. For this purpose sufficient land should be acquired at the very outset and in making calculations regarding requirements of water electricity, power, fuel, transport etc., the possibility of enlarging the units to give a higher production should be kept in view.

43. *Foreign co-operation.*—In view of the facts that (*a*) the industry is to be established for the first time in the country (*b*) the process of manufacture are highly technical and complicated (*c*) the raw materials available in the country have not been properly explored and standardised (*d*) adequate technical advice is not available, foreign co-operation for technical matters in some form or the other would be essential in the initial stages for the industry until it can stand upon its own legs. For the purpose it should be desirable to ask for certain important guarantees from foreign machinery manufacturers regarding production, efficiency and quality of finished product. They should also assist in selecting the best machinery and send their technical experts for erecting the plants and working them in the initial stages. They should, in addition, agree to supply all the technical information available with them and should get investigations carried out in any of the research laboratories abroad with which they may be connected. In any case it is essential, in the opinion of the Panel, that the financial and managerial control of the industry should be with Indians.

44. *Government Aid and Assistance.*—The Panel is of the opinion that if there is likelihood of sufficient private capital forthcoming for the establishment of this industry, it should be allowed to be established and developed on the basis of private enterprise. This, however, should not debar any Provincial or State Government from subscribing a certain percentage of the capital provided the Government concerned is satisfied as to the soundness of the scheme. If the conditions of the money market change and sufficient private capital is not coming forward to establish the industry, on an adequate scale, and in consonance with Indian requirements, then the Central, Provincial or State

Governments should give additional help to the industry by either subscribing larger percentage of the capital, or by giving loans or by guaranteeing a minimum dividend on the capital. In all such cases where the Government either subscribes a certain proportion of the capital or gives other guarantees as indicated above, it should have the liberty to nominate its representatives on the Boards of Directors of the concerns or to appoint special officers to look after their proper working. The nature of the assistance rendered by the Government to the industry and the manner of its representation on the Directorate of the concerns should be decided, from time to time, by a competent authority after reviewing the conditions prevailing at the time and in conformity with the general industrial policy of the Government. In addition to this form of assistance the Panel strongly urges upon the Provincial and State Governments to assist the promoters of rayon industry in other ways, such as acquisition of land raw material contracts supply of technical information, cheap power supply water rights, registration of companies, etc.

45. **Protection.**—Regarding protection for the industry, the Panel is of the opinion that the Government should promise to give adequate protection to the industry in the form of protective duties, bounties, subsidy or any other means, the exact method and manner of such assistance to be decided by the Tariff Board. The Panel considers that the Government should take steps from time to time to examine the working of the industry in regard to its efficiency conditions of employment etc., to ensure that the industry is being run on sound and efficient lines.

In view of the fact, that the Indian rayon industry may use imported sulphite wood pulp in the initial stages, the Panel feels that the import of sulphite wood pulp used specifically for rayon manufacture should be allowed duty free, until the indigenous production is able to meet the requirements of the rayon factories established in India. The drawback duty rebate system is considered suitable for this purpose. The Ponel is also of the opinion that import duty on chemicals used in rayon manufacture should be appreciably reduced.

The Panel further recommends that the Government should allow an adequate depreciation on rayon machinery, which wears out quicker on account of its being run continuously throughout the year. The depreciation fixed should be such that the entire capital cost of the plant should be written off in 10 years of working. In this connection it is of interest to note that rayon factories in U.K. and U.S.A. are allowed fairly high rates of depreciation on rayon machinery.

RESEARCH AND TECHNICAL TRAINING.

46. **Research.**— The rapid development of industries in the Western countries is largely the result of the close co-operation which prevails between science, technology and industry. The Indian industry, on the whole, has not enlisted the aid of science to its help and has not utilised research to improve its processes and finished products. As a result Indian industry has depended largely upon imported machinery and on processes made available by foreign manufacturers. The Panel feels that this is not a healthy state of affairs and should be brought to an end by the development of industrial research aimed at helping the existing industries and fostering new ones.

47. **Co-operative Research.**—In foreign countries, large sums of money are spent by the industry and the Government on research every year. More than 28 co-operative research institutes, besides the Government and university laboratories, are functioning in England. Facilities for industrial research are still more numerous in the United States of America. The larger factories have their own departments of research besides contributing large sums of money for co-operative laboratories. The result has been that the growth of industry in these countries has been phenomenal and the quality of goods has

steadily improved while costs of manufacture have been brought down, thereby enabling them to capture foreign markets.

48.—It has been repeatedly emphasised before that (a) rayon manufacture is a very technical and complicated process (b) the utlisation and exploitation of the Indian raw materials have not been systematically studied (c) the costs of manufacture under Indian conditions have not been worked out and (d) no technical experts for rayon manufacture are available in the country. In order to overcome all these difficulties, the Ponel considers that extensive research work should be initiated on various problems of the rayon industry. Research assumes special significance for the development of this industry, because the Indian rayon industry is bound to experience keen competition from the foreign manufacturers especially U.S.A. and U.K. in the post-war period. The Panel therefore strongly recommends that large sum of money should be spent on rayon research. In this connection the Panel feels that expenditure on research should be shared both by the industry and the Government and that research should be on co-operative lines.

49. **Central Cellulose Research Centres.**—In order to foster rayon research in right earnest this Panel strongly recommends that the Government of India should establish two Cellulose Research Centres on the lines of the co-operative research laboratories established in England for such industries as glass, textiles, woollens, leather etc., at a very early date. The proposed Centres should undertake all problems connected with industries which use cellulose, in one form or the other and for which adequate research facilities are not available at present in the country. One of these Centres should concentrate on problems relating to the manufacture of pulps of different kinds by chemical and mechanical processes, while the other Centres should study research problems relating to the utilisation of these pulps in the various consuming industries such as rayon, plastics, explosives etc. It is advantageous to split the research work at two Centres as the problems relating to the preparation of pulp from raw materials like bamboo, linters, woods, grasses, etc. constitute a distinct set from the problems relating to the utilisation of these pulps. This division of research work has been carried out in the U.S.A. where a number of institutes are carrying on work only on the preparation of chemical and mechanical pulps without studying the problems relating to their utilisation which are investigated in separate institutes. From the geographical point of view also this proposal has an advantage in so far as the raw material producing areas from which pulps can and will be made are not generally situated near those areas which, from other considerations, may be regarded as suitable for the establishment of rayon factories. It is always an advantage to have a research institute fairly near to the consuming or utilisation centres so that a direct contact is maintained between the research workers and those who are interested in the industrial development of the materials. It is recommended that these two Centres should work in close collaboration with one and other and avoid duplication as far as possible.

50. The schemes for these two Centres should be prepared by an expert committee or committees. Regarding location of the first Centre, the Panel feels that Dehra Dun, where a separate section already exists at the Forest Research Institute for paper and pulp research, would be an ideal site. At this Centre researches on the preparation of pulps of different types and qualities would be carried out. Since Dehra Dun Forest Research Institute already possesses the Paper and pulp Section, further work on the utilisation of pulps for the manufacture of these articles may also be located in this centre. However, as regards the utilisation of pulps for other purposes such as rayon, plastics, explosives etc., it would be an advantage to locate this Centre some where near Bombay as it will be more central to the various industries consuming pulp , which are likely to spring up in the future. Furthermore, a

good deal of work is now being done on the finishing problems of textiles and since some of the problems relating to spinning, weaving, dyeing, finishing etc., are common to cotton and rayon, it would be an advantage to have the second institute near a large textile centre such as Bombay where the inter-action of the two industries and the study of the problems common to them may be carried out profitably. In addition, specific problems of research may be given to universities or other centres where facilities for such research are available.

51. **Immediate Problems of Research.**—For solving the immediate problems of the rayon industry the Panel makes the following recommendations:—

(i) The Government of India should take immediate steps to instal a pilot plant (having a capacity of 100 lbs. per batch) for the production and processing of rayon yarn. This pilot plant should be complete in every respect, beginning with the preparation of pulp from Indian raw materials including linters and having sections for spinning, weaving, dyeing, finishing of the yarn and fabrics. It should be located in a suitable building near a textile centre, preferably in Bombay, and should be capable of dealing with the problems of viscose as well as acetate rayon. In view of the fact that samples of pulp prepared at the Dehra Dun Centre will be ready in the near future, the Government should instal this pilot plant as early as possible so that these samples may be tested as regards their suitability in the manufacture of rayon. It would be advantageous if the two Centres start functioning at about the same time.

(ii) The Government of India should immediately sanction the installation of a pilot plant for the preparation of chemical wood pulp by the sulphite process. In this connection, it is understood that the Paper and Pulp Research Section at the Forest Research Institute, Dehra Dun, already possesses a pilot plant for the preparation of pulp by the sulphate process and arrangements are being made to import a pilot plant for the sulphite process. The Panel is therefore of the opinion that research work on the preparation of pulp both by sulphite and sulphate process should be carried out at Dehra Dun under adequate supervision. When the semi-commercial pilot plant recommended by the Panel, is set up, the indigenous pulps prepared at Dehra Dun should be tried out on this plant.

(iii) The Government of India should take steps to constitute a technical committee containing among others, representatives of the Board of Scientific and Industrial Research, the Indian Central Cotton Committee, the Central Sugar Cane Committee and the Forest Research Institute to sponsor cellulose research in India.

52. **Technical Training.**—There is no denying the fact that there is at present an acute dearth of technical personnel in India. It is more so in the case of the rayon industry, where not a single Indian can claim to be an expert. When plans for the establishment of this industry are afoot, it is essential that due attention should be paid to the training of technical personnel.

The Panel strongly feels that the Government of India should send for the next few years 12 young Indians (6 chemists and 6 engineers) abroad every year for specialised training in rayon manufacture. They should be selected on Provincial and State basis. These trainees should preferably be trained in factories manufacturing rayon. Besides this the foreign manufacturers supplying rayon plants in India should undertake to train a few Indian personnel at their works, which should be made a condition of purchase of machinery from them.

The Panel feels that foreign technical experts should be invited to India to train Indian personnel. This could be easily arranged with the machinery manufacturers.

The proposed Cellulose Research Centres when established should have a section for the training of technicians in the spheres of work assigned to them. These technicians should be admitted as apprentices in rayon factories, and should subsequently be employed on reasonable terms.

SUMMARY OF RECOMMENDATIONS.

The Panel is of the opinion that India is very favourably placed for the establishment of the rayon industry.

2. The pre-war consumption of rayon in India was between 60 to 70 tons per day. In order to cover the pre-war demand by indigenous production, the Panel is of the opinion that there is easily room for 6 to 7 rayon factories (each having a daily production capacity of 10 tons) in India in the immediate post-war period with a possible addition of another 4 to 5 factories as the requirements increase owing to an increase in population and rise in the standard of living.

3. Units of 5 and 10 tons production capacity per day are considered most suitable for this country, in view of the need of developing the different regions and spreading out factories over a wide area.

4. Six out of these seven factories should be for the manufacture of viscose rayon (yarn and staple fibre). In view of the modern trend of increased use of union fabrics, at least one factory should be for the manufacture of acetate rayon.

5. The Panel feels that India is very favourably placed with regard to cellulose which is the basic raw material for rayon manufacture, although extensive research work has to be carried out to work out the technical details, to estimate the cost of manufacture of the pulp and to standardise the quality of pulp produced from indigenous raw materials. Under these circumstances the Panel recommends that rayon manufacture may, in the initial stages, be started by using imported wood pulp. The Panel however strongly feels that the use of indigenous raw materials should be encouraged and developed simultaneously with the establishment of the rayon industry so that India may not remain dependent upon foreign suppliers for an essential raw material.

6. As no reliable statistical data on the availability of cellulose raw materials is available, the Panel recommends that the Government should arrange for the carrying out of an immediate survey of all cellulosic raw materials including soft and hard wood, bamboo, grass, other reeds, cotton linters, cotton wastes etc., available in the country.

7. The Panel recommends that the Government should take steps to establish a semi-commercial plant of a capacity of about 100 lbs. per day for preparing the pulp and about 100 lbs. per day for spinning the yarn, complete in every respect.

8. In view of the large quantities of chemicals needed in the manufacture of rayon, the Panel feels that there should be close co-ordination in the execution of the plans and recommendations of this Panel with those of the Heavy Chemicals Panel.

9. Regarding purchase of rayon machinery, the Panel is of the opinion that the Indian industrialists intending to purchase rayon machinery from abroad should make a thorough investigation, with the help of technical experts, of the type, efficiency and productive capacity of the plants for which the quotations are submitted to them. The present restrictions on exchange should be relaxed at as early a date as possible in order that quotations may be obtained in a free and competitive market and the choice of the Indian buyers may not be restricted to certain types of machinery.

10. Machinery and plants worth about Rs. 15 crores will be required for the proposed seven units each of 10 ton daily production capacity. The cost of buildings, erection etc., will be extra.

11. The Panel feels that good use can be made in the country of Japanese rayon machinery, which may fall to India's lot by way of reparations.

12. The Panel considered a large number of sites for rayon factories. This point was also considered at a joint meeting of the Panel with the representatives of Provinces and States, and the following sites are considered tentatively as being suitable locations for rayon factories in India. It should, however, be mentioned that the Panel had no opportunity of inspecting any of these sites and that proper surveying should be done before a particular site is finally selected:—

1. Kalyan, North Kanara, and Bhutkal in Bombay.
2. Chanda and Hoshangabad Districts in Central Provinces and Berar.
3. Kangra District in the Punjab.
4. Banbassa area for acetate factory and Rihand Scheme area for viscose factory in the United Provinces.
5. Near Mettur Dam or Nellore District in Madras.
6. Near Calcutta in Bengal.
7. Cuttack District in Orissa.
8. Sind (for acetate factory).
9. Near Krishnarajasagar Dam in Mysore State.
10. Travancore State.
11. Hyderabad State.
12. Rewa State (pulp factory in the first instance).

13. The Panel recommends that the Government should promise to give adequate protection to the industry in the forms of potective duties, bounties subsidy, or any other means, the exact method and manner of such assistance to be decided by the Tariff Board.

14. The Panel recommends that in the initial stages, until normal conditions return and prices quoted by foreign machinery manufacturers are brought down to reasonable levels, the rayon industry should be relieved of the import duty on machinery.

15. In view of the fact that the Indian Rayon Industry may use imported sulphite wood pulp in the initial stages, the Panel feels that the import of sulphite wood pulp used specifically for rayon manufacture should be allowed duty free. The draw back duty rebate system is considered suitable for this purpose.

16. The Panel recommends that two research centres for cellulose research should be established by the Government.

17. The Panel recommends that the Government of India should send 12 young Indians (6 chemists and 6 engineers) abroad every year for specialised training in rayon manufacture. These trainees should preferably be trained in factories manufacturing rayon.

Nazir Ahmad . Chairman.
Shantidas Askuran
Gautam Sarabhai
M. P. Bhargava
P. N. Sinha
M. Subba Rao
Rasiklal J. Chinai
} Members.

A. S. Bhatnagar . . Secretary.

APPENDIX I.

Production of continuous filament rayon in World and in selected countries 1911—1942. †

Year	United States	Japan	Germany	Italy	Great Britain	France	Other	World total	Percentage change from preceding year
	Million pounds	Million pounds	Million pounds	Million pounds	Million pounds	Million pounds	Million pounds	Million pounds	Million pounds
1911	·4	..	*	*	*	2·6	15·7	18·7	..
1912	1·1	..	*	*	*	2·9	15·8	19·8	5·9
1913	1·8	..	7·7	·3	6·6	3·3	5·5	25·2	27·3
1914	2·4	..	3·5	*	4·0	2·0	7·8	19·7	—21·8
1915	3·9	..	2·2	*	4·0	·9	7·5	18·5	—6·1
1916	5·8	..	5·5	*	3·5	1·6	7·0	23·4	26·5
1917	6·5	..	6·6	*	3·8	1·2	6·1	24·2	3·4
1918	5·8	·1	8·8	·4	3·0	1·4	6·4	25·9	7·0
1919	8·3	·1	7·7	·7	4·8	1·8	4·4	27·8	7·3
1920	10·1	·2	5·2	1·6	6·0	3·4	6·6	33·1	19·1
1921	15·0	·2	7·7	3·2	9·0	4·4	8·7	48·2	45·6
1922	24·1	·5	11·0	6·6	14·5	6·8	13·1	76·6	58·9
1923	35·0	·8	14·3	11·0	17·0	7·7	17·2	103·0	34·5
1924	36·3	1·4	23·2	17·6	24·7	13·2	21·9	138·3	34·3
1925	51·0	3·2	26·0	30·8	29·8	14·3	30·2	185·3	34·0
1926	62·7	5·0	21·7	36·8	25·5	19·2	37·8	211·7	14.2
1927	75·6	10·5	41·3	53·8	38·8	24·2	50·9	295·1	39·4
1928	97·2	16·6	48·9	57·3	52·1	29·9	58·5	360·5	22·2
1929	121·4	26·0	58·4	71·3	52·7	41·8	62·6	434·2	20·4
1930	127·3	36·6	59·0	66·3	47·0	50·6	64·4	451·2	3·9
1931	150·9	48·3	61·9	74·2	52·7	44·0	67·7	499·7	10·7

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† Taken from the pamphlet "Survey of development and use of rayon and other synthetic fibres" issued by the Department of Agriculture, U.S.A.

* Separate data not available. Production if any included under "other."

APPENDIX I—*contd.*

Production of continuous filament rayon in World and in selected countries 1911—1242.

Year	United State	Japan	Germany	Italy	Great Britain	France	Other	World total	Percentage change from proceeding year
	Milion pounds	Million pounds	Million pounds	Million pounds	Million pounds	Million pounds	Million pounds	Million pounds	Million pounds
1932 . .	134·7	69·8	58·0	62·3	69·9	50·6	72·0	517·3	3·5
1933 . .	213·5	98·3	62·9	73·4	80·0	57·0	78·3	663·4	28·2
1934 . .	208·3	153·1	84·9	85·8	88·9	57·2	94·3	772·5	15·4
1935 . .	257·6	224·3	97·7	85·7	112·2	61·5	102·1	941·1	21·8
a1936 . .	277·6	275·0	99·0	86·0	116·8	59·5	109·4	1,023·1	8·7
1937 . .	321·7	334·3	125·0	106·0	119·7	66·4	126·3	1,200·0	17·3
*1938 . .	257·6	209·6	140·0†	101·4	106·4	61·8	111·3†	988·3	—8·12
*1939 . .	328·6	239·4	160·0	119·0	120·0	56·2	122·31†	1,145·5	11·6
1940 . .	390·1	225·0	250·0†	100·0	100·0	†	78·96†	1,144·0	0·1
1941§ . .	451·2	..	..	..	..	..	..	1,300·0	13·6
1942§ . .	479·3	300·0	220·0†	132·0	90·0	69·5	156·4	1,447·2	11·3
1943 . .	501·1	..	..	..	..	..	..	..	..

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† Figures for Germany include production of Austria, 1938-42, Czechoslovakia, 1939-42& Poland 1940 and 1942& Belgium, France, Hungary, Netherland, Norways Rumania, 1940.

§ Data for 1941 and 1942 for foreign countries are, estimates. Data for European countries for 1942 are from Bureau of Foreign ad Domestic Commerce.

APPENDIX II.

Production of rayon staple fibre in World and in selected countries, 1929-1943.

Year.	United States.	Japan.	Germany.	Italy.	Great Britain	France.	Other.	World Total.
	Million Pounds	Million Pounds	Million Pounds	Million Pounds	Million Pounds	Million Pounds	Milion Pounds	Million Pounds
1929 . . .	·5	..	2·4	1·7	2·6	..	..	7·2
1930 . . .	·3	..	4·4	·7	·8	..	..	6·2
1931 . . .	·9	..	4·4	1·4	·8	·5	..	8·0
1932 . . .	1·1	·6	3·0	9·4	1·2	1·6	·4	17·3
1933 . . .	2·1	1·0	8·8	11·0	2·4	2·2	·4	27·9
1934 . . .	2·2	4·7	15·8	21·6	2·4	4·4	·7	51·
1935 . . .	4·6	13·6	37·9	67·7	9·3	5·0	1·5	139·9
1936 . . .	12·3	45·8	94·8	110·1	26·2	6·6	2·8	298·6
1937 . . .	20·2	174·2	219·2	156·3	32·7	11W·3	5·3	619·2
1938 . . .	29·9	375·0	330·0	166·9	31·7	10·8	13·3	957·6
1939 . . .	51·3	309·9	440·0*	190·0	60·0	15·5	14·7*	1082·0
1940 . . .	81·1	300·0	575·0*	225·0	50·0	*	5·7*	236·8
W941† . . .	122·0	..	..	..	..	..	..	1480·0
1942† . . .	153·3	400·0	880·0*	330·0	45·0	128·0	89·4*	2025·7
1943 . . .	162·0	..	..	..	..	..	..	..

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* Figures for Germany include production of Czechoslovakia, 1939-42; Poland, 1940, 1941; Belgium, France, Rumania, 1940.

† Data for 1941 and 1942 for foreign countries are estimates. Data for European countries for 1942 are from Bureau of Foreign and Domestic Commerce. Data for 1942 for Germany, Italy and France include casein fibre.

APPEN

Quantity and value of imports of

	1935-36		1936-37		1937-38	
	Quantity in lbs.	Value in Rs.	Quantity in lbs.	Value in Rs.	Quantity in lbs.	Va in Rs.
Artificial Silk Yarn	14,911	8,363	17,629	9,939	31,589	20,535
Artificial silk yarn mixed with other textile or staple fibre excluding silk.	..	..	..	..	..	..
Manufacture—Hosiery, Socks and Stocking made entirely of Artificial silk.	222	424	160	306	415	813
	Yds.		Yds.		Yds.	
Piecegoods made entirely of Artificial Silk.	74,491	18,848	1,02,319	23,826	89,695	21,813
Goods of Artificial Silk mixed with other materials containing 50% or more of cotton.	7,377	2,281	10,918	2,714	14,561	3,339
Containing no cotton or less than 50% cotton.	880	1,122	969	1,042	1,518	1,539
Blankets wholly or mainly of Artificial Silk.	..	..	..	..	..	..
Other Sorts	..	540	..	732	..	710
Total Artificial Silk . .	..	31,578	..	38,559	..	48,749
Staple fibre and Yarn Raw (cut fibre and waste).	..	..	..	..	191	87
Yarn :—Made of Staple fibre only .	..	..	..	..	2,422	1,924
Made of Staple fibre mixed with other textile fabrics.	..	..	..	..	69	127
Total of Yarn . . .	..	..	..	..	..	..
Total of Staple Fibre and Yarn	..	..	..	..	..	..
Fabrics containing gold or silver-threads.	..	67	..	16	..	4

DIX III

artificial silk in India 1935-36 to 1942-43.

1938-39		1939-40		1940-41		1941-42		1942-43	
Quantity in lbs.	Value in Rs.	Quantity in lbs.	Value in Rs.	Quantity in lbs.	Value in Rs.	Quantity in lbs.	Value in Rs.	Quantity in lbs.	Value in Rs.
17,248	9,588	30,764	21,205	33,889	26,482	13,719	15,521	201	323
169	166	418	387	233	219	66	64	..	..
202	327	114	210	58	189	64	263	5	33
Yds.		Yds.		Yds.		Yds.		Yds.	
28,593	9,828	54,320	21,066	53,456	24,471	27,729	16,804	1,124	1,536
3,810	1,125	5,053	1,641	3,463	1,387	1,920	901	53	78
1,239	1,066	1,634	1,161	1,358	1,403	916	1,051	143	276
55	60	33	48	9	14	6	14	..	1
..	201	..	144	..	271	..	279	..	58
..	22,361	..	45,862	..	54,436	..	34,897	..	2,305
340	158	509	255	52	49	527	848	1	2
2,255	2,008	6,820	5,408	9,876	8,295	4,809	6,354	20	25
4	4	10	10	11	10	..	..	..	..
..	..	..	..	9,887	8,305	4,809	6,354	20	25
..	..	..	..	9,939	8,354	5,336	7,202	21	27
...	97	..	..	..	2	..	3	..	..

N.B.—Value is given in thousands of Rupees. Quantity is given in thousands of lbs. or thousands of Yards.

APPENDIX IIIA

Quantity and value of imports of artificial silk in India from Japan 1935-36 to 1941 -42.

	1935-36		1933-76		1937-38		1938-39		1939-40		1940-41		1941-42	
	Quantity in lbs	Value in Rs.	Quantity in lbs	Value in Rs.	Quantity in lbs	Value in Rs.	Quantity in lbs	Value in Rs.	Quantity in lbs	Value in Rs.	Quantity in lbs	Value in Rs.	Quantity in lbs	Value in Rs.
Artificial Silk Yarn	9,956	5,306	15,129	8,438	28,238	8,193	6,509	4,127	21,876	15,663	32,490	25395	12,724	12,742
Artificial silk yarn mixed with othe textile or staple fibre excluding	..	..	..	..	..	..	157	133	405	351	233	219	66	64
***Manufacture* Silk**														
Hosiery Socks and Stockings made entirely of artificial silk.	205	327	146	229	383	659	188	259	103	154	33	77	27	62
Piecegoods made entirely of artificial silk.	Yards 73,732	18,432	Yards 101,446	23,276	Yards 88,455	20,968	Yards 26,291	8,707	Yards 51,615	19,545	Yards 51,351	2 2,733	Yards 24,779	1 ,463
Goods of artificial silk mixed with other materials containing 50% or more cotton.	5,120	1,310	10,110	2,121	13,971	2,886	3,450	823	4,653	1,321	3,151	1, 091	1,666	654
Containing no cotton or less than 50% cotton.	617	721	644	656	1,024	837	823	548	1,219	719	877	850	376	330
Blankets wholly or mainly of artificial silk.	..	..	..	..	..	..	43	46	33	48	7	11	6	10
Other sorts	..	300	..	586	..	583	..	61	..	79	.	200	..	185
Total Artificial Silk	..	26,396	..	35,306	..	44,127	..	14,804	..	37,890	..	50,576	..	29,530
Staple Fibre and Yarn—Raw (cut fibre and waste).	..	..	..	..	179	80	31	14	455	212	16	8	435	783
Yarn : made of staple fibreonly	..	..	..	..	2,416	1,920	2,117	1,912	6,793	5,375	1,695	8,1 61	4,809	6,353
Yarn : made of staple fibre mixed with other textile fabrics.	..	..	..	..	69	127	4	4	9	9	11	10	..	..
Total of Yarn .	..	..	..	..	2,485	2,047	2,121	1,916	6,802	5,384	9,706	8,171	4,809	6,353
Total of staple fibre and yarn	..	..	..	..	2,664	2,127	2,152	1,930	7,257	5,596	9,722	8,178	5,244	7,136
Fabrics containing gold and silver threads.	..	1	..	1	..	..	..	59	..	..	..	..	..	..

N.B.—Value is given in thousands of Rupees.
Quantity is given in thousands of lbs. or yards.]

APPENDIX IV

Rayon Weaving Mills

No.	Looms	Name
1	157	Abdul Karim Mills, Bombay.
2	269	Ahmed Silk Mills, Bombay.
3	54	Alliance Silk Mills, Bombay.
4	92	Bajaj Textile Mills, Bombay.
5	138	Bharat Mills Silk Ltd., Bombay.
6	300	Bipin Silk Mills Ltd., Bombay.
7	29	Bombay Silk Mills, Bombay-5.
8	202	Dhanamall Silk Mills, Surat.
9	56	Garden Silk Weaving Factory, Surat.
10	31	Indianese Silk Mills Co., Bombay.
11	107	Jasmine Mills Ltd., Bombay.
12	68	Khetani Textile Industries Ltd., Bombay.
13	18	Kothari Silk Mills, Bombay.
14	96	Mahalaxami Mills Ltd., Bhavnagar (Kathiawar).
15	207	Maharana Mills Ltd., Porbunder, (Kathiawar).
16	160	Mahendra Silk Mills Ltd., Ahmedabad.
17	293	Manhar Mills Ltd., Bombay.
18	120	Master Silk Mills, Kathiawar.
19	28	Mohanlal Silk Mills, Bombay.
20	36	Narendra Silk Mills, Bombay.
21	202	Nanikram Sobhraj Mills Ltd., Ahmedabad.
22	100	National Art Silk Mills Ltd., Bombay.
23	57	New Era Textile Mills Ltd., Bombay.
24	152	New India Rayon Mills Co., Ltd., Bombay.
25	76	New Laxminarayan Silk Mills, Ahmedabad.
26	66	New Mahalaxmi Silk Mills, Ltd., Bombay.
27	110	Panalal Silk Mills, Bombay.
28	72	Prabhat Silk & Cotton Mills Ltd., Surat.
29	100	Ramlal Silk Mills, Bombay.
30	50	Rohit Mills Ltd., Ahmedabad.
31	50	Secunder Sari & Silk Mills, Bhiwandi (Dist. Thana).
32	64	Sharda Silk Mills Ltd., Bombay.
33	108	Shree Laxami Silk Mills, Bombay.
34	300	Shree Shakti Mills Ltd., Bombay.
35	20	Shree Shanti Silk Mills, Bombay.
36	112	Surat Silk Goods Mills, Surat.
37	32	Venus Silk Mills, Bombay.
38	90	Vinod Silk Mills, Bombay.
Total	4,209	looms.

Silk and art silk mills in the Punjab (suitable weaving Rayon goods).

No.	Looms	Name
1	157	Amritsar Rayon & Silk Mills, Amritsar.
2	63	Mehra Textile Mklls, Amritsar.
3	83	Khanna Silk Mills, Amritsar.
		(Partially suitable for weaving rayon goods)
4	57	Indian Woollen and Silk Mill s, Amritsar.
5	24	Kapur Silk Weaving Mills, Amritsar.
6	20	Krishan Textile Mills, Amritsar.
7	53	Hindustan Embroidery Mills, Amritsar.
.	12	New India Embroidery Mills, Amritsar.

APPENDIX V

Per capita consumption of cotton & Rayon in 1937[*]

	in lbs. Country.	Cotton.	Rayon.
1	U. S. A.	23.1	2·88
2	United Kingdom	17.3	2·51
3	India	3.5[†]	0·10

Consumption of rayon increased to 4432 lbs. per head in U. S. A. in 1941.

APPENDIX VI

[‡] *Consumption of rayon and fibre per head.*

	lbs
Germany	6·49
Japan	5·30
Italy	3·82
Australia	3·08
United States	2·83
United Kingdom	2·44
New Zealand	2·43
Switzerland	1·97
Sweden	1·91
Canada	1·76
Czecho-Slovakia	1·73
Netherlands	1·36
Belgium	1·50
France	1·24
Denmark	1·14
Trinidad	1·04
Eire	0·80

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[*] Silk and Rayon August 44.

[†] In 1935.

[‡] From 'Silk and Rayon'—March 1944.

APPENDIX VII

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APPENDIX

Particulars regarding

Serial No.	Variety of seed	Place where delinted	Gin saw or roller.	First cut, Second cut or Mill.	Price per md. of 82² lb.
1	4F	Khanewal	Saw	First Cut	Rs. 5 to 6 locally and loose.
2	4F	Mailsi	"	"	Rs. 5/8/- "
3A	4F	Vihari	"	"	" " "
3B	289F	"	"	"	Rs. 6/- " "
4	20% Desi 80% P.A.	Okara	"	..	..
5	50% Desi 50% P.A.	"	"	..	..
6	285 F	Hyderabad Sind	Saw & Roller.	First Cut	Rs. 5/- for.
7	285 F	" "	Mixed	"	..
8	285 F	Navasari	"	Mill run.	..
9	4 F	Burewala	Saw ...	First Cut	Rs. 6/- to Rs. 8/-
10	289 F	Sargodha	"	"	Rs. 5/10/-
11	30% Desi 70% P.A. 70% P.A.	Okara	"	"	..
12	289 F	Mianchannu	"		—
13	4 F	Arafwala	"	"	..
14	4 F	Montgomery	"	..	Rs. 8/- f.o.r.
15	75% 289F 25% 4F	Mianchannu	"	..	..
16	289 F	Khanewal	"	First Cut	Rs. 7/4 including pressing charges.
17	85% 4F 15% Desi	Lyallpur	"	"	Rs. 8/-
18	4 F	Mianchannu	"	"	Rs. 7/-
19	4 F	Khanewal	"	"	—
20	289 F	Sargodha	"	"	Rs. 4/8/-
21	289 F	Mianchannu	"	"	} 1st & 2n quality linters at Rs. 6/-.
22	4 F	"	"	"	" "
23	289 F	"	Roller	"	3rd quality at Rs. 2.

VII

Indian linters of 1939-40.

Delinting machine used.	Linters recovered per ton of seed.	Matching U.S.A. Grade No.		Colour.	Foreign matter.
		Character.	Colour.		
Continental .	45 lb. to 67 lb.	3	..	Greyish white .	Small brown and peppery leaf some stalk, also some boll-rests.
Carvers .	„	2—3	..	„	Some brown & peppery leaf few stalks & some undeveloped green seed.
„	„	4	..	Greyish . .	Small amount of leaf and stalk but fair amount of undeveloped seed ; and some boll-husks.
„	„	I 3 II 1	3 1	I II	Small amount of leaf and a few seeds. Large amount of seed, some black ones (Egyptian).
„	45 l . .	2	..	Greyish white . .	Small quantity of seed & some whole seed.
„	„	3	..	„ .	Fair quantity of small leaf, also small quantity of seed.
„	„	3	..	Dirty yellow .	Fair quantity of brown leaf, some cotton fibres distributed throughout the sample.
„	„	3	..	Very dirty yellow.	Large quantity of leaf and some crushed seed.
„	48 lb. to 56 lb.	6—7	..	Dirty brown .	..
Continental .	18-17 lb.	2	..	Greyish white .	Fair amount of leaf, also some whole & crushed seed—some boil rest also.
„	60 lb. .	3	3	..	Some leaf & some whole & crushed seed.
Varner . .	40 lb. .	2	..	Greyish white .	Slight leaf & a fair quantity of seed.
Continental .	55 lb. .	1	..	Whiter than U.S. Grade No. 1.	Small leaf & a small quantity of undeveloped seed.
„	25-28 lb.	2	..	Whiter than U.S. Grade No. 2.	Slight leaf & a large quantity of whole seed, some of them in clusters.
„	13 lb. .	2	..	Greyish white .	Large quantity of peppery leaf and some crushed seed.
„ .	54 lb. .	1—2	1—2	„ . .	Some leaf & a fair large quantity of crushed seed.
„ .	27 lb. .	2—3	2—3	..	Black peppery leaf & slight crushed seed.
„ .	About 10 lb.	3	..	Greyish white .	Fairly large amount of leaf & some crushed seed.
„ .	41 lb. .	1	..	Whiter than U.S. Grade No. 1.	Fair amount of leaf & some undeveloped seed.
„ .	17 lb. .	2	..	Greyish white .	Some leaf & slight sand.
Carvers . .	54 lb. .	2	..	Whiter than U.S. Grade No. 2.	Small quantity of seed & some whole seed.
Country (self made) delinting machine.	42 lb. .	1		1 ..	Small quantity of leaf as well as whole & crushed seed.
„ .	22 lb. .	2	..	Whiter than U.S. Grade No. 2.	Small quantity of leaf and very small quantity of whole crushed and seed.
„ .	36 lb. .	3	..	Whiter than U.S. Grade No. 3.	Plenty of leaf, stalk and seed.

APPENDIX VIII

Distribution of domestic continuous filament rayon shipments by trades

** United States of America.*

1930—1943.

Year	Knit Goods.			Woven goods.			Miscellaneous.*	Total Shipments
	Hosiery*	Other knit*	Total	Broad Woven and Tires*	Narrow Woven*	Total Woven		
	Million pounds	Million pounds	Million pounds	Million pounds	Million pounds	Million pounds	Million pounds	Million pounds
1930 . . .	16·5	38·0	54·5	49·5	3·0	52·5	4·6	111·6
1931 . . .	21·1	48·7	69·8	75·6	4·0	79·6	6·2	155·6
1932 . . .	19·0	38·0	57·0	84·6	3·9	88·5	6·3	151·8
1933 . . .	17·0	41·3	58·3	141·3	5·5	146·8	5·9	211·0
1934 . . .	14·1	39·9	54·0	131·3	4·8	136·1	4·6	194·7
1935 . . .	14·7	47·9	62·6	179·6	5·2	184·7	5·4	252·7
1936 . . .	16·3	51·0	67·3	217·0	8·2	225·2	4·9	297·4
1937 . . .	12·6	38·9	51·5	202·5	7·4	209·9	4·8	266·2
1938 . . .	14·1	39·6	53·7	209·3	6·7	216·0	4·1	273·8
1939 . . .	16·2	49·9	66·1	278·6	9·1	287·7	5·8	369·6
1940 . . .	16·4	54·0	70·4	304·4	8·2	312·6	5·7	388·7
1941 . . .	26·3	57·9	84·2	349·2	10·2	359·4	8·8	452·4
1942 . . .	49·3	56·3	105·6	343·6	8·7	352·3	10·9	468·8
1943 . . .	49·2	56·1	106·3	360·4	10·4	370·8	18·1	494·2

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*Taken from the pamphlet " Survey of development and use of rayon and other synthetic fibres" issued by the Department of Agriculture, U. S. A.

* a" Hosiery " includes all manufacturers of seamless and full-fashioned hosiery.

*. " Other knit " includes all manufacturers of circular and flat-knit underwear plus other knit goods such as outerwear, sweaters, and knitted dress goods.

*. " Broad wovens " includes all broad-loom weavers whether they be "silk weavers", "cotton weavers,' woolen and worsted weavers" or rayon weavers.

*. " Narrow woven " includes manufacturers of such items as ribbons, tapes, and woven elastic goods, which are of a width narrower than 81 inches.

*. " Miscellaneous " includes all other outlets such as bag, lace and braid manufacturers.

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BRIEF DESCRIPTION OF THE VISCOSE AND ACETATE PROCESSES

BRIEF DESCRIPTION OF THE VISCOSE AND ACETATE PROCESSEES

Viscose Process

Briefly the Viscose process consists of the following operational stages:—

Viscose Rayon Manufacture starts with wood pulp of 88 per cent. to 92 per cent. Alpha-Cellulose content. The raw material is carefully conditioned to standard moisture content and then placed in a steep tank containing dilute caustic soda solution of approximately 17·5 per cent. NaOH and thus becomes Alkali-Cellulose.

This Alkali-Cellulose is then shredded or milled into a light flocculent mass reminiscent of "bread crumbs". The crumbs are then aged and allowed to stand for a specified period of time in a carefully regulated temperature.

Churning is the next operation wherein the Alkali-Cellulose crumbs are allowed to react with carbon bisulphide gas and during the course of which the whole product is slowly rotated in a large cylindrical vessel. The product thus formed is Cellulose Xanthate and is now passed on for dissolving in Caustic Soda. Large mixers are employed in this operation and an intimate dispersal of cellulose in Caustic is produced, the resultant liquor being styled "Viscose". Filtration and ripening then follow wherein the viscose is progressed through large tanks during a specified period of time and at a carefully controlled temperature. Vaccum is applied to the contents before the liquor is finally conveyed to the spinning operation.

In this operation of spinning, the liquor is extruded through very fine jets or spinnerettes into a bath containing acid and mineral salts which decompose the liquor, regenerate the cellulose and the coagulated thread thus produced is taken up over glass rollers and deposited into a box rotating at a high speed which collects the thread in the form of a compact textile package. The yarn is than washed, desulphurised, bleached, softened and finally dried and conditioned to the requisite moisture content. The Rayon Yarn is now a saleable commodity which may be processed to any desired textile form.

Acetate Process.

In the Viscose process briefly described, Cellulose was the basic raw material and the resultant fibre was almost pure cellulose. The problem of manufacture being to render cellulose soluble and to prepare viscose mixture from it with the properties of coagulation after extrusion and in so doing to regenerate the cellulose. In the acetate process, although cellulose is once more the raw material, an acetyl ester of the same is prepared, and is the resulting constituent of the fibre.

Cotton linters or wood pulp are again the source of raw material, the purity and quality being vital to the success of the process.

The raw material is treated with acetic anhydride, glacial acetic acid and a catalyst to form a cellulose acetate which dissolves in the solution. By pouring this fluid into water, it is reprecipitated as a white flocculent mass. This mass is thoroughly washed, dried and then dissolved in acetone to form the spinning liquor.

The process is delicate in so far as strict temperature, time and quantity control must be observed to guarantee a product with constant properties.

In spinning, the usual procedure of extrusion through fine jets is adopted. The solution is forced through the jet in a downward vertical direction the jets being enclosed in tubes into which a current of warm air is inducted, by contact with which the issuing filaments are set by evaporation of the acetone. At the bottom of the tube the filaments are collected and wound on to a bobbin, twist being imparted, to the thread in a subsequent twisting operation.

Unlike, Viscose the yarn is now in a saleable condition and no further operations are necessary to bring out the lustre and purity of thread. In fact, the distinctive properties of acetate yarn are due to the acetic ester content, and should any large proportion be removed, loss of lustre and shrinkage will result. Furthermore, in other processes, the weight of yarn produced in somewhat less than the weight of the original raw material, whereas in acetate there is an increase amounting to 60 per cent. on the weight of the raw material. The appreciation in weight is of course due to the substitution of an acetyl group, weighing 43 times that of every hydrogen atom that is replaced. There is an added advantage in acetate yarn being soluble in acetone, since waste can always be recovered in this manner, and re-spun. Disadvantages occur, however, in dyeing acetate yarn since it is impervious to the dyes used for other rayon, yarns. This may, nevertheless, be put to advantage in cross dyeing effects when acetate is interwoven with some other type of yarn, as alternated warp or weft in the manufacture of piece goods.

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GIPD—L—231I&SD—11-12.47—650,